Fueling Plastics

How Fracked Gas, Cheap Oil, and Unburnable Coal are Driving the Plastics Boom

- Fossil fuels — oil, gas, and coal — are the primary materials from which almost all plastics are made.
- Cheap shale gas in the United States is fueling massive new investments in plastics infrastructure in the US and abroad, with $164 billion planned for 264 new facilities or expansion projects in the US alone. Many projects, including the largest, remain in the construction or planning stages and face significant public opposition.
- China is also investing heavily in plastics infrastructure, including heavy investments in expensive, carbon-intensive coal-to-olefins technology.
- The fracking boom is also fueling new plastics plants in Europe, which will rely heavily on American natural gas.
- A recent wave of plastics investments in the Middle East will further intensify the industry's search for new plastics markets and its efforts to increase plastics consumption.
- By 2025, production capacity is expected to increase by 33-36% for both ethylene and propylene. If constructed, this massive expansion in capacity could lock in plastic production for decades, undermining efforts to reduce consumption and reverse the plastics crisis.

Excess production and consumption of plastic, especially single-use plastics commonly used in packaging, is causing widespread contamination of the environment, including pervasive plastics pollution in the world's oceans. This issue affects marine environments, coastal communities, food chains, and more, harming people and the environment upon which they depend.

Recent shifts in shale gas development in the United States are driving a massive investment in new upstream plastic production facilities which, if constructed, will produce the fundamental materials from which most other plastics are made. This new wave of US investment follows recent or ongoing expansions

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in China, the Middle East, and other parts of Europe and Asia. As the world works to address the growing crisis of plastics in the environment, oceans, and human bodies, it must simultaneously confront the role of expanding plastics production in that crisis. If these facilities get built, they may lock in a world of even cheaper, more ubiquitous, and more disposable plastics for decades to come.

From Fossils to Plastics

Fossil fuels — oil, gas, and coal — are the primary materials from which almost all plastics are made. Because the cost of fossil fuels represents a large share of the cost of plastic, trends in fossil fuel markets heavily influence where companies choose to invest in new production facilities and which facilities they try to build. The two main drivers of investment today are the natural gas boom in the United States and underutilized coal in China.

Although there are many kinds of plastic, the five "standard plastics" constitute approximately 85% of world plastic consumption by weight.[1] These five plastics are:

- polyethylene (32% of global demand);
- polypropylene (23%);
- polyvinyl chloride or PVC (16%);
- polystyrene (7%); and
- polyethylene terephthalate or PET (7%).[2]

Propylene is the primary feedstock for polypropylene; ethylene is the primary feedstock for the other four.[3]

The majority of plastic production by weight, and much of the future of the plastics sector, can therefore be understood by looking specifically at trends in propylene and ethylene production.

Ethylene and Propylene

Ethylene is the most important base chemical in the plastics sector.[4] Ethylene is produced primarily from natural gas liquids (NGL), a by-product of natural gas exploration, or from naphtha, a product of crude oil refining.[5] The choice of feedstock is geographically based — because natural gas is hard to transport, NGL are used primarily in North America and the Middle East, where natural gas is abundant.[6] Naphtha is primarily used in China and Western Europe.[7]

Ethylene is a commodity chemical, and its competitiveness is based on cost. Because approximately two-thirds of the cost of ethylene is the cost of the energy inputs required for its production, the relative competitiveness of ethylene producers using NGL versus naphtha correlates to the relative cost of gas compared to oil. Currently, the cheapest producers are in the Middle East, followed by the United States.[8]

After ethylene, the most important chemical building block of plastics is propylene.[9] The cracking process for both NGLs and naphtha have traditionally produced propylene alongside ethylene. However, many of the new ethylene production facilities, both those planned and in use, are designed only to process ethane, the primary component of NGL. This process produces almost no propylene and has led to concern regarding the "propylene gap" (propylene production in the United States fell 40% from 2005 to 2012).[10] Chemical companies are now building "on-purpose propylene production" (OPP) plants to make propylene directly, instead of as a co-product of ethylene production.[11]

It is also possible to produce ethylene and propylene from coal, although this is rare outside of China. However, China is investing heavily in its coal-to-olefins technology, and this process may expand to become a more significant contributor to the ethylene and propylene markets.[12]

United States

The increased availability of cheap natural gas in the United States has led directly to a drop in the cost of production for ethylene, as ethane (the primary component of NGL) is similarly cheap and abundant. It is difficult to overstate the significance of the natural gas boom to the plastics industry. The fossil fuel and plastics industries view the change as a "once-in-a-generation opportunity" and a "coming renaissance" for North American plastics.[13] The president of the American Chemistry Council — an industry organization that represents major petrochemical companies and plastic resin producers in the United States[14] — further stated, "Thanks to the shale gas production boom, the United States is the most attractive place in the world to invest in chemical and plastics manufacturing. It's an astonishing gain in competitiveness."[15]

Some within the industry are less certain about the prospects for future investment and question the long-term prospects for major new investments in increasingly saturated markets.[16] Still, this internal industry disagreement is not slowing down investments in the US.

This "renaissance" of North American plastics is leading to both an increase in production capacity and a geographic expansion of production facilities. Beginning in 2012,

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the petrochemical industry began making significant investments in ethylene production capacity in the United States to take advantage of cheap chemical feedstocks.[17]

For example, Chevron Phillips has almost completed a $6 billion expansion in Cedar Bayou, Texas.[18] Dow Chemical recently finished construction on its own $6 billion project in Freeport, Texas,[19] and Occidental Petroleum just opened its $1.5 billion ethane cracker in Ingleside, Texas.[20]

These investments are not slowing. In April 2016, the American Chemistry Council announced that by 2023 the chemical industry will spend over $164 billion on 264 new facilities or expansion projects in the United States.[21] At the time, more than half of the projects were still in the planning phase,[22] with several new projects announced since then.[23] For example, in March 2017, Total announced a $1.7 billion joint venture with Borealis and Nova to build a new ethane cracker in Port Arthur, Texas, as well as a new polyethylene plant in Bayport, Texas.[24]

The American Chemistry Council expects investment to continue

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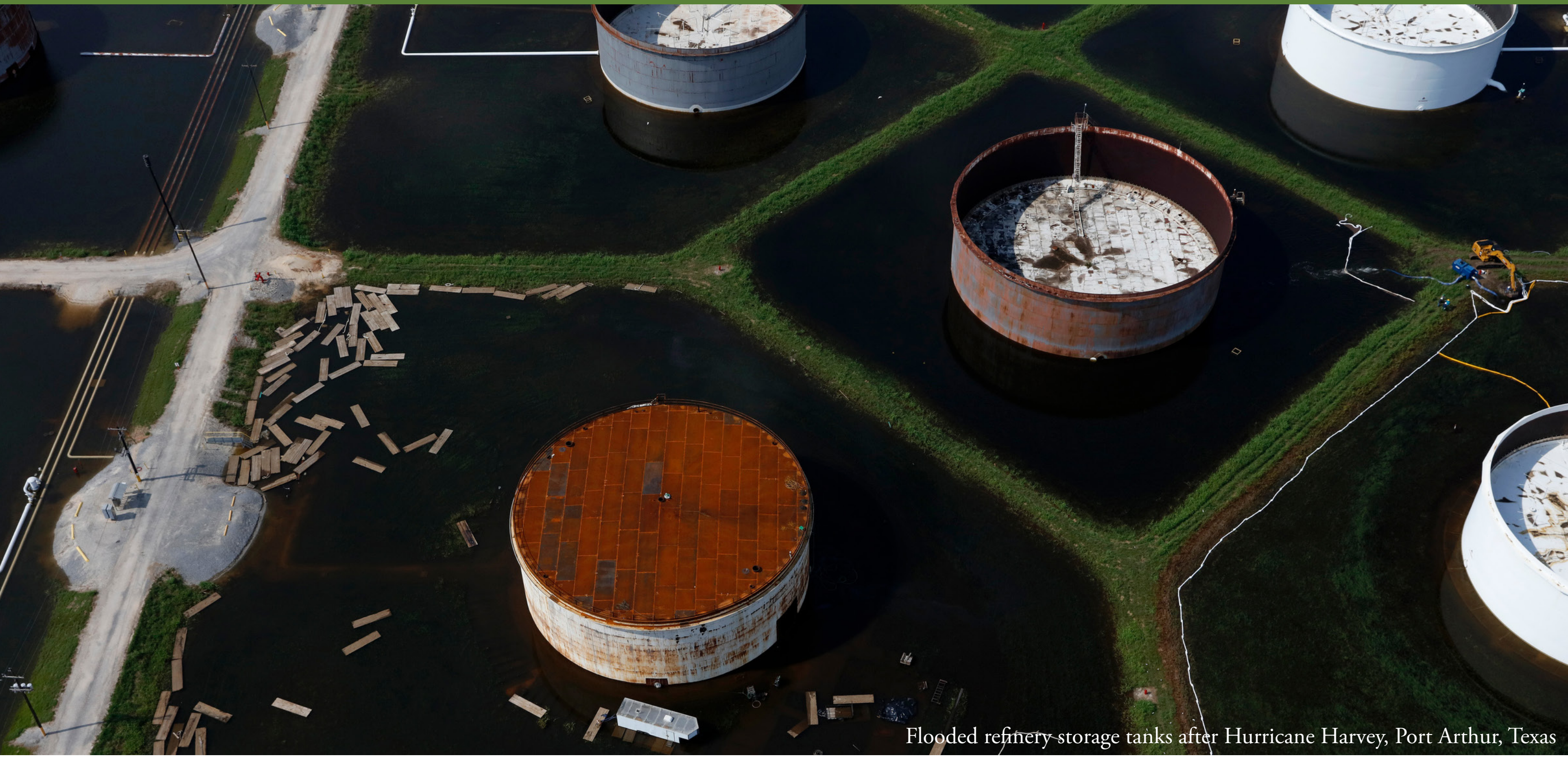

Flooded refinery storage tanks after Hurricane Harvey, Port Arthur, Texas

Aaron Sprecher/Greenpeace

at over a billion dollars annually through at least 2024, peaking at over $9 billion in 2019.[25]

Among the largest group of projects in the US Gulf region is a joint venture by ExxonMobil and Saudi Basic Industries Corporation (SABIC). The deal was inked in Saudi Arabia during the Trump Administration's first overseas trip, and with Rex Tillerson — former CEO of ExxonMobil, now the US Secretary of State — in the room.[26] The $20 billion initiative proposes "11 major chemical, refining, lubricant and liquefied natural gas projects,"[27] including a $10 billion ethane cracker — the largest in the world — to be built in Portland, Texas.[28] This proposed project, however, has been met with fierce resistance from the local community.[29] The project is still in its early stages, and is scheduled to open in 2024.[30]

The industry has proposed over twenty new or expanded crackers and ethylene production facilities

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alone.[31] Before the shale gas boom, many of the crackers in the United States were capable of processing either naphtha or NGLs. Several of those crackers were forced to close due to the relative competitiveness of European and Asian producers. The new facilities being constructed, in contrast, are typically only capable of processing ethane and cannot be used with naphtha, propane, methanol, or other feedstocks.

Whereas most of US ethylene production takes place in the Gulf of Mexico, six new cracking facilities have been proposed for North Dakota, West Virginia, Ohio, and Pennsylvania.[32] Prior to 2017, only three ethane crackers in the United States were located outside of Texas or Louisiana.[33]

In addition to the facilities themselves, fossil fuel and chemical companies are investing in pipelines to move chemical feedstocks. For example, one $2-3 billion pipeline proposed in Pennsylvania has been dubbed the "Plastics Pipeline" by the extensive movement of communities and organizations opposing it.[34] The plastics boom is also driving investments in new export infrastructure. The Port of Houston alone is investing $700 million in expansions to accommodate the plastics export boom.[35]

Europe

Although Europe is an important region of plastics and petrochemical production, no new facilities have been built there for some time. Cheap gas, first in the Middle East and now in the United States, alongside the rise of plastics production in

China, has put European producers at a cost disadvantage.

Breaking this trend, chemical company INEOS recently announced it intends to build a new propane dehydrogenation plant (for producing propylene), possibly in Antwerp, Belgium, as well as expand two other complexes.[36] The proposed Antwerp plant would produce up to 750,000 metric tons of propylene, while the proposed expansions — in Grangemouth, Scotland, and Rafnes, Norway — would add an additional 900,000 metric tons of ethylene capacity.[37] As INEOS Chairman Jim Ratcliffe noted, "These projects represent the first substantial investments in the European chemicals industry for many years."[38]

These projects are made possible because American companies now have the ability to ship liquid natural gas across the Atlantic. European plastics producers, relying on naphtha, are uncompetitive with producers using cheap gas from the Middle East and the United States. However, INEOS plans to use gas from the US in its facilities,[39] dramatically reducing its costs of production. As of June 2017, shipments of US liquefied natural gas began arriving in Europe.[40]

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East Asia

In the mid-2000s, Asia surpassed Europe as the largest plastics-producing region, with the overwhelming majority of that production centered in China.

China is already the world's leading propylene producer[41] and is currently building dozens of plants to turn both gas oil and methanol (from coal) into propylene.[42] Whereas growth in propylene production is projected to grow 2.3% and 4.2% annually in the US and Middle East, respectively, for the next decade, China is expected to increase its propylene production a staggering 6.9% annually through 2025.[43]

China has already increased both its capacity and production of olefins, primarily ethylene and propylene, from coal. From 2011 through 2015, coal-to-olefins capacity grew

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Jinjie Coal Chemical Industrial Park, China nearly 700%, from 1 million to 7.92 million tons annually.[44] Over the same period, Chinese coal-to-olefins output increased from 430 thousand tons to 6.48 million.[45]

China's investment in coal-to-olefins technology is rare and the result of China's lack of natural gas and oversupply of coal. In 2015, BASF was planning to build the first-ever methanol-to-propylene plant outside of China;[46] but by 2016, the project had been postponed.[47]

The development of this technology is extremely important to the future of ethylene and propylene production. In addition to coal, this process would allow natural gas (methane) to be converted into olefins, which may become necessary as demand for fossil fuels decreases. Some observers "expect China to invest more than $100 billion in coal-to-chemicals technology in the next five years,"[48] although at this point, coal-to-olefins production is still significantly more expensive than production using naphtha or NGLs.[49]

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As ICIS petrochemical market analysts have observed, China's heavy investment in this technology may be driven more by labor policy than consumer needs:

"Sitting high on the ethylene cost curve, there is little economic incentive to continue building these high capital cost CTO projects. However, social incentives still exist for building these plants to foster downstream plastic processing as well as upstream coal mining employment in China's poorer interior regions."[50]

These investments also clash with China's expressed environmental goals and its shared planetary interest in a safe climate, as coal-to-olefins production is massively carbon intensive — a fact not lost on industry competitors. Olivier Thorel, VP of global intermediates and ventures at Shell Chemicals, described the process as "massive CO2 machines that make chemicals as a sidestream."[51]

China is also investing heavily in traditional forms of ethylene and propylene production. On its current trajectory, China could consume 90% more crude oil in the production of petrochemicals in 2030 than it did in 2015.[52] By 2020, "unconventional" production is expected to reach 30% and 45% of China's ethylene and propylene production capacity, respectively. Even under this scenario, between half and two-thirds of China's olefin production will still be derived from oil.[53]

The most intense concentration of plastics capacity outside China is in Singapore, which has seen recent major investments from ExxonMobil, among others.[54] In addition, there are currently at least two ethylene projects underway in India, two in Malaysia, and one in South Korea.[55]

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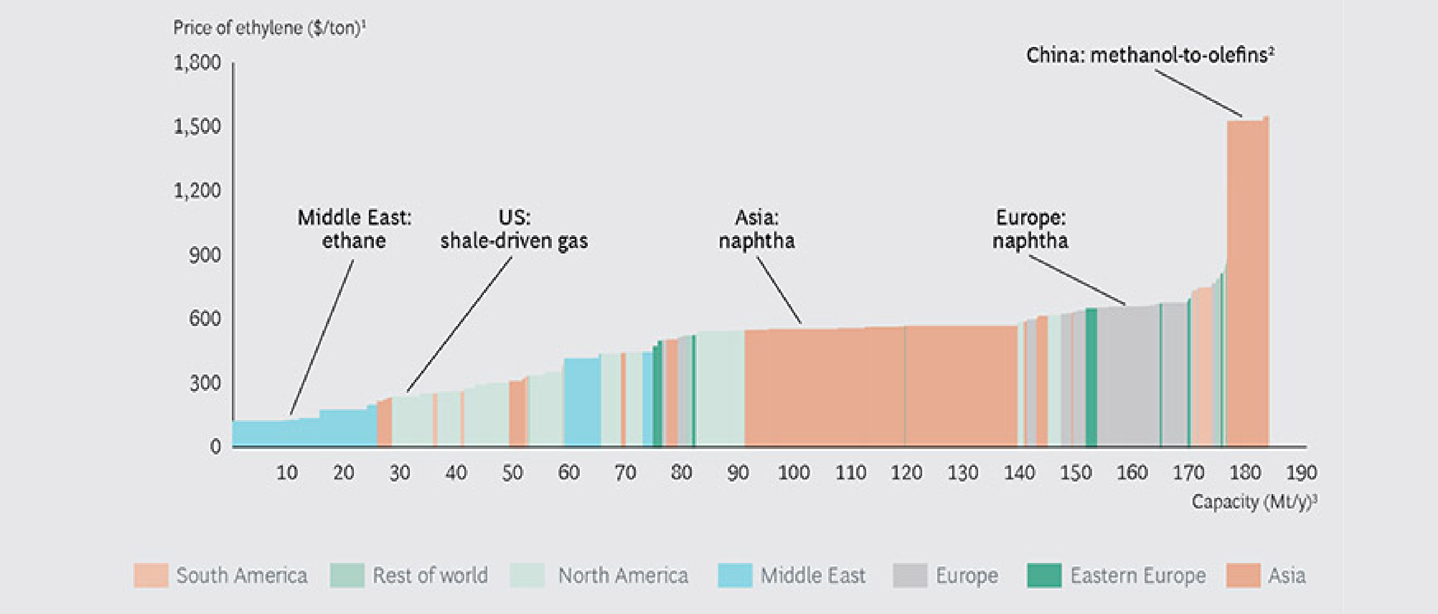
The Middle East and Western Asia

From 2008 to 2016, most olefin capacity expansions were focused on the Middle East. As recently as January 2014, half of new ethylene projects globally were located in the Persian Gulf.[56] Sadara Chemical Company, a joint venture between Dow Chemical and Saudi Aramco, is a $20 billion project in Saudi Arabia that will have a capacity of over 3 million metric tons per year.[57] The joint venture was established in 2011 and is still being constructed.[58]

This period of rapid expansion seems to have ended, as attention has shifted to cheap ethane feedstocks in the United States and investments in China. (Notably, the Portland plant described above is a joint venture between Exxon and SABIC.) Business Monitor International notes that for the Middle East, "the days of new massive olefins projects may be over."[59] Ongoing investments in Oman and Iran, however, suggest this pronouncement may be premature.[60] Although new buildout is slowing, SABIC and Aramco announced in October 2016 the accelerated construction of a direct oil-to-chemicals plant in Saudi Arabia,[61] and Sinopec announced as recently as March 2017 their "strategic agreement to study opportunities for joint projects in Saudi Arabia and China."[62]

Moreover, even as new buildout slows, this heavy recent investment in plastics infrastructure will provide ongoing incentives for the Middle East to maintain and increase its

Projected Supply Capacity and Price of Ethylene from Various Sources, 2018*



Source: BCG petrochemical supply curve model.
[1]Price calculated using a stable oil price of $60/barrel.
[2]Cost data assumes the use of merchant methanol for feedstock. The coal-to-olefin route is likely to be cheaper—as low as $850/ton at current coal prices.
[3]Mt/y = millions of tons per year.

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plastic production and search for new plastics markets.

Conclusion

The shale gas boom in the United States, together with growing production in China spurred in part by coal-to-olefins technology, is driving global investment in new ethylene and propylene production facilities.

By 2025, global production capacity for ethylene is projected to grow from 170 million metric tons to 230 million tons. Capacity for propylene could rise from 120 to 160 million tons.[63] In total, production capacity for these critical plastic feedstocks is poised to grow by 33% or more in less than a decade.[64]

Many new plants have already been built, bringing with them the need to identify or create new markets, new consumers, and an ever-growing flow of plastic packaging and waste. Many more remain in the planning and construction phases and may be challenged or halted, due to public opposition, financial risk, or changing market forces. If all of this production capacity is constructed, it may lock in a massive expansion of cheap plastic production for decades.

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This over-construction and overproduction creates a serious risk that plants will become less profitable over time. Once built, however, this infrastructure will operate, locking in incentives for the petrochemicals industry to produce a flood of new plastics for decades to come.

With expanded plastics production and consumption will come more spills and emissions from chemical plants, more plastic clogging shorelines and killing marine life, and more micro-plastic particles — and the pollutants they may absorb[65] — finding their way into food chains and tap water. Just as importantly, it will perpetuate a fossil fuel economy that underpins both the climate crisis and the plastics crisis, while impacting frontline communities and the wider public at every stage of its toxic lifecycle.

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